SPECIFICATION **SUBSTITUTE SPECIFICATION**

PAPER MACHINE

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a paper machine for papermaking and particularly to a structure of a press part for pressing a wet web formed in a wire part to dewater the wet web and a dryer part for drying the wet web dewatered in the press part.

2. Description of the Related Art:

In line with recent increased demand for a high-speed paper machine, there is proposed a no-open-draw paper machine in which a wet web is transferred from the former to the press unit, always being supported by a press felt, an impervious transfer belt, or a dryer canvas (a DRY felt). A no-open-draw paper machine is a paper machine having no open draw, that is, a state in which a wet web is never transferred in the air freely without being supported. The no-open-draw structure can minimize air resistance to a wet web during transfer so that the wet web can be sufficiently protected from tearing even when a paper machine is working at high speed.

Such a no-open-draw paper machine is disclosed in,

for example, publications of United States Patent Number (hereinafter abbreviated to USPN) 4,483,745, USPN 5,792,320, USPN 5,951,821. FIG. 3 schematically shows a side view between the last press and the first dryer group of the paper machine appearing in publications of USPN 5,951,821 and USPN 5,792,320. A web formed by a non-illustrated former is pressed by a press 101 upstream to be dewatered and then sent to a last press 102.

At the top side of the last press 102, a top felt belt 102a made of water-absorbing felt runs around a suction pick-up roll 102b and a top press roll 102c. Meanwhile, an impervious belt 102d made of an impervious material runs around a bottom roll 102e and other rolls.

In the paper machine with such a structure, a wet web 120 sent from the upstream presses 101 is sucked by the suction pick-up roll 102b to adhere to the top felt belt 102a and then transferred by the top felt belt 102a to be introduced to the last press 102. Both surfaces of the wet web 120 are pressed through the nip between the top press roll 102c and the bottom press roll 102e to be dewatered, and water drained off from the wet web 120 is absorbed by the top felt belt 102a.

A dryer part 103 is installed downstream of the last press 102. In the dryer part 103, a wet web 120, which has been transferred on the impervious belt 102d, is sucked by a suction pick-up roll 103b thereby clinging to a dryer canvas 103a. A suction box 104 arranged at the inside of the

loop-shaped canvas 103a sucks the wet web 120, which clings to the canvas 103a. In this state, the canvas 103a transfers the wet web 120 to a first dryer cylinder 103e. After passing the first dryer cylinder 103e, the wet web 120 is turned by a turning roll 103f and then transferred to a second dryer cylinder 103g. In the same manner, the wet web is alternately transferred downstream along a dryer cylinder and a turning roll, which do not appear in the drawing. While the wet web 120 is transferred along the dryer cylinders and the turning rolls, the wet web 120 gradually becomes dried by being pressed by the dryer canvas 103a.

Application of pressure to the wet web 120 in the press part including the last press 102 in order to dewater the wet web 120 reduces the thickness of the wet web 120 and, at the same time, slightly extends the wet web 120 in the direction (e.g., the transfer direction of the wet web 120) perpendicular to that of the pressure application. Such extension is generated on the wet web 120 each time pressure is applied to cause an accumulated elongation of the wet web 120. As a result, the wet web 120 becomes more elongated as the wet web 120 is transferred downstream in the transfer direction of the wet web 120 whereupon the tension of the wet web 120 gradually decreases.

As a solution, transfer speed of the suction pick-up roll 103b is set to be higher than the transfer speed of the wet web 120 from the last press 102 so that the wet web 120 is drawn between the suction pick-up roll 103b and the last

press 102 in order to absorb the elongation of the wet web 120.

In the paper machine of FIG. 3, elongation (slackness) of the wet web 120 on the dryer canvas is mainly classified into first longitudinal elongation caused when the dryer canvas 103a disengages from the first dryer cylinder 103e and second longitudinal elongation caused when the wet web 120 is dried by contacting with the dryer cylinders (especially, the second dryer cylinder). Hereinafter, the first and second longitudinal elongation will be described individually.

The first longitudinal elongation will now be described in conjunction with a system for removing water from the wet web 120 at the dryer part 103.

The wet web 120 received by the suction pick-up roll 103b is sent to downstream dryer cylinders 103e, 103g... in succession to be pressed onto the outer surfaces of the dryer cylinders 103e, 103g... by the dryer canvas 103a. At that time, the outer surfaces of the dryer cylinders 103e, 103g... are smooth enough to allow the wet web 10 to cling to the outer surfaces because of the presence of water, paper dust and sticky materials (hereinafter called water and so forth) on the surface of the wet web 120.

When the wet web 120 clinging to the outer surface of a dryer cylinder is about to disengage from the outer surface, a part of the water and so forth on the surface of the wet web 120 remains on the outer surface of the dryer cylinder. The remaining water and so forth on a portion of the outer

surface is removed from the surface by being scraped off by a doctor blade or the like or by being dried until the portion comes into contact with the wet web 120 again due to the rotation of the dryer cylinder (namely, the amount of the removed water and so forth is substantially identical to that of the remaining water and so forth whereby the outer surface of the dryer cylinder is in an equilibrium state).

As mentioned above, the wet web 120 clings to the outer surface of the dryer cylinders 103e, 103g.... Above all, since a larger amount of water and so forth adheres to the outer surface of the first dryer cylinder 103e, the wet web 120 tends to cling to the outer surface of the first dryer cylinder 103e with ease.

For this reason, even after the wet web 120 clinging to the first dryer cylinder 103e passes a separation point of the dryer canvas 103a from the first dryer cylinder 103e and is no longer pressed to the first dryer cylinder 103e by the dryer canvas 103a, the adhesive force of the wet web 120 overcomes the centrifugal force thereof and the wet web 120 adheres to and is transferred together with the outer surface of the first dryer cylinder 103e as the broken line of FIG. 3 shows. When a portion of the wet web 120 is transferred adhering to the outer of the cylinder surface, the tension of the portion gradually increases to disengage the wet web 120 from the first dryer cylinder 103e. However, at this time, the wet web 120 generates elongation, that is first longitudinal elongation.

A pressure difference generating apparatus (exemplified by a suction box) 105 is installed near to the separation point A of the first dryer cylinder 103e, facing the wet web with the dryer canvas 103a interposed. The pressure difference generating apparatus 105 sucks the wet web 120 onto the dryer canvas 103a so that the wet web 120 is inhibited from adhering to the first dryer cylinder 103e after the separation point A.

In order to assist the pressure difference generating apparatus 105, a paper-separation doctor 106 and an air jet 106a are disposed downstream of the separation point A in the rotational direction of the cylinder so as to face the first dryer cylinder 103e. The tip of the paper-separation doctor 106 and air jetted from the air jet 106a extricate the wet web 120 adhered to the outer cylinder surface from the surface. The turning roll 103f, which guides the wet web 120 from the first dryer cylinder 103e to the second dryer cylinder 103g, generates a negative pressure around the surface thereof so that the centrifugal force of the wet web 120 running around the turning roll 103f does not disengage the wet web 120 from the turning roll 103f, thereby avoiding attachment of the wet web 120 to the first dryer cylinder 103e.

It is sure that such a structure reduces first longitudinal elongation, but it is impossible to inhibit first longitudinal elongation completely.

As the wet web 120 is drying as the wet web 120 proceeds

through the dryer part, progressing reductions in viscosity of the water on the wet-web surface and in amount of the sticky materials cause a sudden decline of the adhesive force of the wet web 120 to the outer surface of a dryer cylinder. As a result, at the second and its downstream dryer cylinders, the wet web 120 generates slight first longitudinal elongation due to adhering to the outer surfaces of these cylinders.

Next, the second longitudinal elongation is caused by expansion of water contained in the wet web 120, which water is heated as the wet web 120 is transferred in contact with the dryer cylinders 103e and 103g. Generally, such longitudinal elongation is generated to a larger degree at the second dryer cylinder 103g and downstream dryer cylinders thereof than at the first dryer cylinder 103e. This is because the wet web 120 being transferred along the first dryer cylinder 103e is not heated to so high a temperature, so that the water contained in the wet web 120 does not expand very much.The wet web 120 being transferred along the second and downstream dryer cylinders 103g is heated to so high a temperature that the water in the wet web 120 expands a lot. The longitudinal elongation caused by expansion of contained water is called the second longitudinal elongation, which is largely generated on the wet web 120 when transferred along the second dryer cylinder 103g while the first longitudinal elongation is generated mainly at the first dryer cylinder 103e.

When the wet web 120 has passed only several dryer cylinders, the wet web 120 generates such first and second

longitudinal elongation and thereby goes slack on the dryer canvas 103a. If a slack portion of the wet web 120 is pressed onto a dryer cylinder, creases are made on the portion of the wet web 120 and stress concentration on a folding line of the creases is enough to tear the wet web 120.

The publication of USPN 5,888,354 discloses a technique that enables to inhibiting slackness caused by the first longitudinal elongation.

The technique, a part of which is shown in FIG. 4, has no open draw between a former (not shown) and a first dryer cylinder 202a, and elongation of a wet web 120 caused during a pressing and dewatering process performed in a press part including a last press 201a and other elements is taken in by transferring the wet web 120 at different speeds in the press part so as to draw the wet web 120. A felt belt 201c used for the last press 201a is stretched to the first dryer cylinder 202a, and a dryer canvas 202b runs around a second dryer cylinder 202d and a turning roll 202c. With this structure, it is possible to draw the wet web 120 between the first dryer cylinder 202a and the second dryer cylinder 202d whereupon the first longitudinal elongation caused at the first dryer cylinder 202a can be absorbed.

However, the technique does not release elongation of the wet web 120 in the transfer direction, which elongation is caused at the last press 201a generating the highest dewatering pressure (nip pressure), immediately downstream of the nip. Microcorrugation is therefore generated on the

wet web 120, and the wet web 120, with compressive strain caused by the microcorrugation, is sent to the first dryer cylinder 202a.

After that, when a paper machine runs, especially at a high speed, elongation resulting from compressive strain is released from the wet web 120 between the points C and D, between which neither the felt belt 201c nor the dryer canvas 202b press the wet web 120 with respect to the first dryer cylinder 202a. As a consequence, the wet web 120 is extricated from the outer surface of the first dryer cylinder 202a between the points C and D, thereby causing the wet web 120 to become largely slack at the outer surface of the first dryer cylinder 202a, as shown by the interrupted line in FIG. 4. The separation point at which the wet web 120 starts disengaging from the outer surface of the first dryer cylinder 202a between the points C and D varies based on various conditions, such as a centrifugal force acting on the wet web 120, the adhesive force and/or a compression strain amount of the wet web 120, and/or a nip pressure between the first dryer cylinder 202a and a nip roll 201b. Slackness due to disengagement of the wet web 120 is unstable in behavior and causes tearing, making stable high-speed working of a paper machine difficult.

It is conceivable that the speed of the first dryer cylinder 202a is set to be higher than that of the last press 201a (in other words, the wet web 120 is drawn (stretched so as not become slack) therebetween), so that the compressive

strain generated on the wet web 120 downstream from the last press 201a and the resultant slackness of the wet web 120 caused between the point C and D are removed. However, in order to set the speed of the first dryer cylinder 202a higher than that of the felt belt 201c, the nip between the nip roll 201b and the first dryer cylinder 202a has to be released by departing the nip roll 201b from the first dryer cylinder 202a and the nip pressure has to be reduced by reducing the pressure of the nip roll 201b applied to the first dryer cylinder 202a.

In this case, pressure of the felt belt 201c applied to the wet web 120 with respect to the first dryer cylinder 202a becomes inadequate and stable transfer of the wet web 120 to the first dryer cylinder 202a cannot be realized.

As mentioned above, even in a no-open-draw paper machine that is able to work at a high speed, wet-web tearing resulting from the first and second longitudinal elongation generated in the dryer part is unavoidable, making the operation of the in paper machine unstable. As a result, high-speed operation cannot be realized in a conventional paper machine.

SUMMARY OF THE INVENTION

With the foregoing problems in view, the object of the present invention is to provide a paper machine that prevents wet web from going slack in order to stably work

at a high speed.

As a first generic feature, there is provided a paper machine comprising a plurality of belt mechanisms for transferring a wet web which is formed by a wire part Each of the belt mechanisms has a belt for supporting the wet web and a driving unit for driving the belt together with the wet web. A press part includes one or more press units, arranged along a transfer path of the web, for pressing the wet web so that the wet web is dewatered. A dryer part includes a plurality of dryer units arranged along the transfer path of the wet web for drying the wet web, which has been dewatered in the press part, by heat. A last press unit, that is, the most downstream one of the one or more press units along the transfer path of the wet web in the press part, a first dryer unit, that is, the most upstream one of the plural dryer units along the transfer path of the wet web in the dryer part, and a second dryer unit, that is, the second upstream one of the plural dryer units along the transfer path of the wet web in the dryer part, are associated with three of the belt mechanisms, respectively. The driving units of the respective different belt mechanisms, which are associated with the last press unit, the first dryer unit and the second dryer unit, respectively, are individually controlled so that a transfer speed of the wet web along each of the last press unit, the first dryer unit and the second dryer unit is individually set.

As a first preferable feature, the transfer speed of

the wet web along the first dryer unit may be set to be higher than the transfer speed of the wet web along the last press unit, and the transfer speed of the wet web along the second dryer unit may be set to be higher than the transfer speed along the first dryer unit. With these settings, it is possible to prevent the wet web from going slack upstream and downstream of the first dryer unit so that high-speed papermaking can be realized.

As another preferable feature, the transfer speed of the wet web along the first dryer unit may be set to be higher than the transfer speed of the wet web along the last press unit by a factor equal to or less than 1.04. As an additional preferable feature, the transfer speed of the wet web along the second dryer unit may be higher than the transfer speed of the wet web along the first dryer unit by a factor equal to or less than 1.01.

These preferable features can effectively prevent the wet web from tearing, respectively or in combination, and can concurrently realize high-speed stable operation of the paper machine.

As a further preferable feature, the dryer part may have one or more other dryer units other than the first and second dryer units, which other dryer units are arranged downstream of the first and second dryer units. The second dryer unit and one of the other dryer units may be associated with two of the belt mechanisms, respectively. A transfer speed of the wet web along the last-named dryer unit may be

set to be higher than the transfer speed of the wet web along the second dryer unit by a factor equal to or less than 1.01. As a result, longitudinal elongation caused by heat mainly at the second dryer unit can be absorbed whereupon the wet web is further effectively prevented from going slack.

Other objects and further features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view schematically illustrating the main portion of a paper machine according to a first embodiment of the present invention;

FIG. 2 is a side view schematically illustrating a part of the paper machine of FIG. 1; and

FIGS. 3 and 4 are schematic side views individually illustrating configurations from a last press roll to the entrance of a dryer part of conventional paper machines.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings.

First embodiment:

FIGS. 1 and 2 are side views illustrating a paper machine

according to a first embodiment of the present invention: FIG. 1 shows a side view of the paper machine; and FIG. 2, a side view of a part of the paper machine of FIG. 1.

As shown in FIG. 1, the main portion of the paper press of the present invention includes a wire part (a paper forming process) X, a press part (a dewatering process) Y and a dryer part (a drying process) Z in this order along the direction of transfer of a wet web. The paper machine has no open draw (i.e., no non-supported space at which a wet web is not supported by any part included in the paper machine) between the wire part X and the downstream exit of the press part Y. Although not shown in an accompanying drawing, the paper machine further includes calendering and reeling processes downstream of the dryer part Z in this order. A web dewatered and dried in the press part Y and the dryer part Z passes through the calendering process to smooth the surface thereof and through the reeling process whereupon the web is made into a reeled paper product.

The wire part X comprises a flow box 1 to flow pulp suspension (a mixture of fibers and dispersant water) serving as a paper material solution, a pair (two sheets) of endless meshes (wires) 2 and 3 that run in synchronization with each other, a suction roll 4 and a wire roll 5 opposing each other upstream of the paper forming process being interposed by the pair of meshes 2 and 3, drainage devices 6 and 7 facing each other and disposed downstream of the suction roll 4 and of the wire roll 5, and a suction roll 8.

The mesh 2 is supported by the suction roll 4, a wire roll 51 and a number of guide rolls 53 and is driven or guided by each of the rolls 4, 51 and 53 so that the mesh 4 moves. Similarly, the mesh 3 is supported by the wire roll 5, a wire roll 52 and a number of guide rolls 54 and travels by being driven or guided by each of the rolls 5, 52 and 54.

In the wire part X, the pulp suspension jetted from the flow box 1 is jetted to a space between the pair of meshes 2 and 3 that are to be introduced between the wire roll 5 and the suction roll 4 and is transferred sandwiched between the meshes 2 and 3. During transfer, water contained in the pulp suspension is drained off by the drainage devices 6 and 7 and is sandwiched between the meshes 2 and 3, so that between pulp fibers and dispersant water are separated and a wet web is formed.

The subsequent stage of the press part Y includes a pair (two sheets) of endless felt belts (belts) 12 and 13 upstream and another pair (two sheets) of endless felt belts (belts) 18 and 19 downstream.

The felt belt 12 aligned most upstream in the press part Y runs around two suction rolls 11, a press roll 14 and a number of guide rolls 55 so as to form a loop. One of the suction rolls 11 and the press roll 14 has a driving motor (a driving unit) to drive the felt belt 12 together with a wet web as well as with these rolls. The felt belt 12 travels in accordance with driving or guidance of these rolls 11, 14 and 55. With this structure, a wet web is supported by

the felt belt 12 during transfer and the combination of the felt belt 12 and these rolls 11, 14 and 55 serves as one of the belt mechanisms of the present embodiment.

The felt belt 13 opposite to the felt belt 12 runs around a press roll 15, a suction roll 16 and a number of guide rolls 56 in a loop shape. One of the press roll 15 and the suction roll 16 includes a driving motor (a driving unit) so that the felt belt 13 travels in accordance with driving or guidance of these rolls 15, 16 and 56. The combination of the felt belt 13 and these rolls 15, 16 and 56 serves as another one of the belt mechanisms of the present embodiment.

A wet web on the mesh 3 is transferred downstream in the wire part X and then picked up by the suction roll 11 to move to the felt belt 12 so that the wet web is dewatered by pressure applied by the press rolls 14 and 15 when sandwiched between the felt belts 12 and 13, which are respectively included in the belt mechanisms of the present embodiment, on the transfer path. The press rolls 14 and 15 serve as a press unit of the present embodiment.

The wet web passed through between the press rolls 14 and 15 is completely moved to the felt belt 13 by a suction force of the suction roll 16 acting on the web at a separation point between the felt belts 12 and 13. The wet web is further picked up by a suction force of a suction roll 17 to be sent to a top felt belt 18, which is arranged downstream in the press part Y.

The top felt belt 18 runs around the suction roll 17,

a press roll 20 and a number of guide rolls 57 so as to form a loop. One of the suction roll 17 and the press roll 20 has a driving motor (a driving unit) so that the top felt belt 18 is driven or guided by these rolls 17, 20 and 57 to move. Facing the top felt belt 18, a bottom felt belt 19 is installed so as to form a loop by running around a press roll 21 and a number of guide rolls 58. The press roll 21 has a driving motor (a driving unit) and the bottom felt belt 19 travels due to driving or guidance of these rolls 21 and 58.

The combination of the felt belt 18 and the rolls 17, 20 and 57 serves as one of the belt mechanisms of the present embodiment; and similarly, the combination of the felt belt 19 and the rolls 21 and 58, serves as another one of the belt mechanisms.

The wet web moved to the felt belt 18 is sandwiched between the traveling felt belts 18 and 19 to be transferred downstream and is further dewatered by being pressed by the last press (i.e., a combination of the press rolls 20 and 21). Namely, the pair of the press rolls 20 and 21 function as a press unit of the first embodiment. The wet web passed through between the press rolls 20 and 21 moves onto the felt belt 19 and is further moved to the dryer part Z by a suction pick-up roll 23.

However, the most downstream press is preferably a shoe press instead of the press rolls 20 and 21. Additionally, the bottom felt belt 19 is preferably substituted with an impervious transfer belt to avoid rewetting (water squeezed

from a wet web being absorbed by the wet web again).

As shown in FIG. 1, the upstream portion of the dryer part Z includes endless canvas (belts) 22a to 22c, wet-web turning rolls (hereinafter sometimes simply called turning rolls) 23a to 23c, dryer cylinders (dryer units) 25a to 25d, and suction boxes 27a to 27d. Vapor is supplied to the inside of each of the dryer cylinders 25a to 25d from a non-illustrated external vapor source. The wet web 10 transferred from the press part Y is successively pressed onto the outer surface of each dryer cylinder 25a to 25d by the canvases 22a to 22c and is gradually dried.

The most upstream canvas 22a is disposed so as to be opposite to the most upstream dryer cylinder (hereinafter also called the first dryer cylinder) 25a, serving as the first dryer unit. The canvas 22a runs around the suction pick-up roll 23 and a number of guide rolls 59 and thereby forms a loop shape. The outer circumference of the canvas 22a is partially pressed by the first dryer cylinder 25a. The canvas 22a is supported by the suction pick-up roll 23, the dryer cylinder 25a and the guide rolls 59, and the canvas 22s is driven by the suction pick-up roll 23 or the dryer cylinder 25a, whereupon the canvas 23a travels in accordance with guidance by the guide rolls 59.

The canvas 22b downstream of the canvas 22a is opposite to the second upstream cylinder (hereinafter called the second drier cylinder) 25b, serving as the second dryer unit, and the third upstream cylinder (hereinafter called the third

dryer cylinder) 25c. The canvas 22b is supported and driven/guided by the cylinders 25b and 25c, the turning rolls 23a and 23b and a number of guide rolls 60 to move.

The canvas 22a, the dryer cylinder 25a and the guide rolls 59 function as an integrated form of one of the belt mechanisms and one of the dryer units of the present embodiment. Similarly, the canvas 22b, the cylinders 25b and 25c, turning rolls 23a and 23b and the guide rolls 60 make an integrated form having one of the belt mechanisms and one of the dryer units of the present embodiment.

The canvas 22c, entry of which only appears in FIG. 1, is arranged so as to be opposite to the cylinder (hereinafter called the fourth dryer cylinder) 25d fourth upstream in the direction of transfer of a wet web. The canvas 22c is supported and driven/guided by the fourth dryer cylinder 25d, turning roll 23c, and a number of guide rolls 61 to travel.

Hereinafter, the dryer part Z will now be described in detail with reference to FIG. 2, in which the interrupted line represents the wet web 10 for convenience.

The wet web 10 being transferred along with the bottom felt belt 19 of the last press unit is picked up by the suction pick-up roll 23 interposed by the canvas 22a associated with the first dryer cylinder 25a. After that, the wet web 10 is pressed onto the first dryer cylinder 25a by the canvas 22a.

A wet-web sucking device (in the illustrated example, a suction box for generating a negative pressure) 27a is installed along a portion of the inside of the loop-shaped

canvas 22a between the suction pick-up roll 23 and the first dryer cylinder 25a. The suction box 27 sucks up the wet web 10 onto the canvas 22a in order to avoid disengagement of the wet web 10 from the canvas 22a while the wet web 10 is transferred from the suction pick-up roll 23 to the first dryer cylinder 25a.

The canvas 22a presses the wet web 10 onto the portion between the points H and K of the outer surface of the first dryer cylinder 25a (that is, the canvas 22a is pressed onto the outer surface of the first dryer cylinder 25a between the points H and K with the wet web 10 interposed therebetween). The canvas 22a disengaged from the outer surface of the first dryer cylinder 25a (at the point K) enters a return loop to travel along a stretching unit, a cleaning unit and other units, which do not appear in the accompanying drawing, and finally returns to the suction pick-up roll 23.

A guide roll 60a that is the closest to the first dryer cylinder 25a among the guide rolls 60 that guide traveling of the second canvas 22b includes a non-illustrated shifting mechanism so that the guide roll 60a can move forward and backward with respect to the first dryer cylinder 25a in the direction shown by the arrow in FIG. 2. Adjustment of the position of the guide roll 60a adjusts a part of the transfer path of the second canvas 22b. A part of the transfer path of the second canvas 22b is set such that the second canvas 22b is in the closest proximity to or in kiss touch with the outer surface of the first dryer cylinder 25a at point L.

Further, adjustment of the position of the guide roll 60a adjusts the gap width between the second canvas 22b and the first dryer cylinder 25a, and also adjusts the degree of the kiss touch (the nip pressure or the contact amount) of the second canvas 22b with the first dryer cylinder 25a. Such adjustment of the position of the guide roll 60a is carried out in accordance with various conditions, such as type of wet web 10 or transfer speed, such that the wet web 10 does not go slack.

Here, the point L represents the disengagement point at which the wet web 10 disengages from the first dryer cylinder 25a if the second canvas 22b does not press the wet web 10 onto the first dryer cylinder 25a. Being in kiss touch stands for a substantial point contact between the second canvas 22b and the first dryer cylinder 25a so that the nip pressure between the second canvas 22b and the first dryer cylinder 25a is substantially equal to zero.

The outer surface of the first dryer cylinder 25a is covered with ceramics so that the pressed wet web 10 disengages from the surface with ease. Doctor blades 28 and 29 and an air jet 35 are disposed at a rotational portion (here, the bottom outer surface) of the first dryer cylinder 25a, which portion does not contact with the wet web 10 being transferred. The edges of doctor blades 28 and 29 contact with the outer surface of the first dryer cylinder 25a allowing the rotation of the first dryer cylinder 25a, and the air jet 35 shoots air jets onto the cylinder outer surface. The doctor blade

28, upstream in the cylinder rotation and the air jet 35 disengage the possible wet web 10 sticking on the outer surface of the first dryer cylinder 25a downstream of the point L from the outer surface of the first dryer cylinder 25a. Meanwhile, the doctor blade 29 downstream in the cylinder rotation scrapes off the extraneous matter to clean the cylinder outer surface. Keeping the cylinder outer surface clean stabilizes behavior of the wet web 10 when shifting to the next stage (e.g., disengagement of the wet web 10 from the cylinder outer surface at a substantially constant point).

The second canvas 22b, after passing the point L is pressed onto the outer surface of the second dryer cylinder 25b through the outer surface of the wet-web turning roll 23a. After that, the second canvas 22b passes downstream along the wet-web turning roll 23b, the third dryer cylinder 25c, and the guide rolls 60, and further along a stretching unit, a cleaning unit and other unit, which do not appear in the accompanying drawing, and finally returns to the guide roll 60a.

A wet-web sucking device (in the illustrated example, a suction box for generating a negative pressure) 27b is installed along the inside of the loop-shaped second canvas 22b. The wet-web turning roll 23a generates negative pressure around the outer surface of the turning roll 23a so that the wet web 10 and the second canvas 22b are sucked onto the outer surface of the wet-web turning roll 23a together whereby the wet web 10 can be stably passed over to the second canvas

22b from the first canvas 22a.

In order to realize stable traveling of the wet web 10 along the outer surface of the first dryer cylinder 25a between the points K and L, the second canvas 22b preferably has an air permeability of 1,000-4,000 cc/cm^2·min@1/2"AQ (i.e., an air permeability of 1,000-4,000 cm^3/cm^2·min at a differential pressure of 124.5 Pa).

As mentioned above, the last press consisting of press rolls 20 and 21, the first dryer cylinder 25a and the second dryer cylinder 25b are individually associated with upstream belt mechanisms whereupon the felt belts 18 and 19 for the last press, the canvas 22a for the first dryer cylinder 25a and the canvas 22b for the second dryer cylinder 25b can be set to move at respective different speeds. In other words, it is possible to set individual speeds of the wet web 10 being transferred along the last press and the first and second dryer cylinders 25a and 25b, so that the wet web 10 can be drawn respectively between the last press and the first dryer cylinder 25a and between the first dryer cylinder 25a and the second dryer cylinder 25b.

Here, the canvas 22a travels along the first dryer cylinder 25a at a speed V_1, which is set to be higher than the speed V_0 of the last press traveling (i.e., the traveling speed of the top and bottom felt belts 18 and 19) by a factor equal to or less than 1.04 (i.e., $V_0<V_1\leqq 1.04V_0$), concerning longitudinal elongation (approximately 3%) of the wet web 10 caused at the last press so that the wet web 10 can be

drawn between the last press and the first dryer cylinder 25a. For this purpose, a driving unit able to set the traveling speed of the canvas 22a in the above range is selected as the driving unit (a motor to rotationally drive the suction pick-up roll 23 or the first dryer cylinder 25a) to drive the canvas 22a. A speed V_1 in excess of 1.04 times V_0 causes the wet web 10 to be excessively drawn, lowering the stiffness of the wet web 10. Excessive drawing may be a cause of tearing of the wet web 10 in a downstream dryer cylinder and make it difficult to work the paper machine at a high speed. Therefore the speed V_1 is preferably higher than the speed V_0 by a factor equal to or less than 1.03.

The speed V_2 of the canvas 22b traveling along the second and third dryer cylinder 25b and 25c is set to be higher than the speed V_1, for example, by a factor equal to or less than 1.01 (i.e., $V_1 < V_2 \leqq 1.01V_1$), concerning a possible first longitudinal elongation (equal to or less than 1%, normally 0.5%), which has been referred to as a problem in conventional techniques, so that the wet web 10 can be drawn between the first dryer cylinder 25a and the second dryer cylinder 25b. For this purpose, a driving unit able to set the traveling speed of the canvas 22b in the above range is selected as the driving unit (a motor to rotationally drive one of the wet-web turning rolls 23a and 23b and the dryer cylinders 25b and 25c) to drive the canvas 22b.

Further, in the illustrated example, the fourth dryer cylinder 25d is associated with a belt mechanism different

from that associated with the second and third dryer cylinders 25b and 25c, as described above. This can individually set a traveling speed for each of the canvas 22b (for the second and third dryer cylinders 25b and 25c) and the canvas 22c (for the fourth dryer cylinder 25d) to move at. In other words, it is possible to set individual speeds of the wet web 10 along both the second and the third dryer cylinders 25b and 25c and along the fourth dryer cylinder 25d, respectively.

Generally, the temperature of a wet web sharply rises while a wet web is transferred along several drier cylinders upstream in the dryer part Z and then the wet web attains equilibrium at approximately 80℃. After that, the remaining water in the wet web is evaporated at a constant temperature. Assuming that the temperature of the wet web 10 is 20℃ when entering the dryer part Z, the coefficient of expansion of the water is approximately 2.7% if the water temperature rises from 20℃ to 80℃. The degree of expansion differs according to the direction because of orientation of wet-web fibers. On the assumption that the wet web uniformly expands in every direction, the coefficient of expansion is converted into the coefficient of linear expansion of approximately 1%. In other words, the second longitudinal elongation of the wet web 10 is approximately 1%.

In order to absorb (take in) the second longitudinal elongation of the wet web 10, the speed V_3 of the canvas 22c traveling along the fourth dryer cylinder 25d is set to be approximately 1.01 times as high as the speed V_2 of the upstream

canvas 22b. A driving unit able to set the traveling speed V_3 of the canvas 22c is selected as the driving unit (e.g., a motor for rotationally driving the third drier cylinder 25c) for driving the canvas 22c.

In the dryer part Z, since the wet web 10 generates a second longitudinal elongation until the wet web 10 attains the equilibrium at 80℃, each dryer cylinder is preferably associated with a dedicated canvas loop and a dedicated driving source to drive the dedicated canvas loop (that is, an individual belt mechanism is preferably provided for a dedicated one of the dryer cylinders). However, as described above, the rising in temperature (i.e., the second longitudinal elongation) of the wet web 10 is high at the entry of the dryer part Z but the temperature of the wet web scarcely rises in the downstream dryer part Z. A result of the Inventor's experimental use of a pilot machine reveals that it is possible to prevent the wet web 10 from going slack by installing at least one belt mechanism to drive a drier cylinder disposed downstream of the second dryer cylinder 25b separately from the belt mechanism to drive the second dryer cylinder 25b such that an elongation generated in at least the second dryer cylinder 25b is absorbed.

In the paper machine of the first embodiment having the above mentioned structure, when a wet-web elongation generated at the last press is absorbed by setting the transfer speed V_1 of the wet web 120 transferred together with the first canvas 22a to be higher than the transfer speed V_0 of the wet

web 120 transferred along the last press ($V_0<V_1$), the wet web 10 generates a first longitudinal elongation similar to a conventional technique, which elongation can however be absorbed by setting the transfer speed V_2 of the wet web 120 transferred together with the second canvas 22b to be higher than the transfer speed V_1 of the wet web 120 transferred together with the first canvas 22a ($V_1<V_2$).

The wet web 10 does therefore not go slack on the canvas 22b when being transferred to the second dryer cylinder 25b so that substantially the entire portion of the wet web 10 being transferred together with the second canvas 22b is supported by the second canvas 22b, the wet-web turning roll 23a and the second dryer cylinder 25b. As a result, it is possible to almost-completely avoid slackness of the wet web 10, which is a cause of creases resulting in stress concentration, so that tearing of the wet web 10 can be inhibited.

Here, the third canvas 22c, which is different from the second canvas 22b running around the second and third dryer cylinder 25b and 25c, runs around the fourth cylinder 25d whereby the traveling speed of the second canvas 22b can be set separately from the traveling speed of the third canvas 22c.

While the wet web 10 is gradually heated and dried while proceeding in the dryer part Z, the above-mentioned second longitudinal elongation is generated at and downstream of the second dryer cylinder 25b (especially, at the second

dryer cylinder 25b). The second longitudinal elongation can be absorbed by setting the speed of the third canvas 22c to be higher than the speed of the second canvas 22b, so that the wet web 10 can be drawn between the third dryer cylinder 25c and the wet-web turning roll 23c. As a result, it is possible to prevent the wet web 10 from going slack on the third canvas 22c and further from being torn.

With this structure and driving manner, the wet web 10 can be stably transferred in the dryer part Z even at a high speed, so that frequency of tearing is greatly reduced as compared with a conventional technique. As a result, it is possible to run the paper machine at as high a wet-web transfer speed as 2,000 m/min, for example.

Further, the paper machine of the present invention should be by no means limited to the foregoing embodiment, and various changes or modifications may be suggested without departing from the gist of the invention.

A belt mechanism is shared by the second dryer cylinder 25b and the third dryer cylinder 25c in the first embodiment. Alternatively, the second dryer cylinder 25b and the third dryer cylinder 25c may be associated with different belt mechanisms and the wet web 10 may be drawn between these dryer cylinders 25b and 25c. With this alternative configuration, it is possible to early absorb the second longitudinal elongation generated on the wet web 10 at the second dryer cylinder 25b.

The speeds V_0, V_1, V_2 and V_3 of the felt belt 18 and

19, and the canvas 22a, 22b and 22c should be by no means limited to the ranges described above, and alternatively can be set to appropriate values so as to absorb elongations of the wet web 10.